RESONANT INELASTIC X-RAY SCATTERING PROBING SIGNATURES OF ELECTRON-LATTICE INTERACTION IN MANGANITES

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INTRODUCTION

Resonant inelastic x-ray scattering (RIXS) in the hard x-ray regime has recently emerged as a powerful tool in the study of valence electron excitations in strongly correlated transition metal oxides. The discovery of large enhancements of the inelastic scattering on tuning the incident x-rays to the 'resonance' frequency, i.e. an incident energy near one the absorption edges, and the advances in third generation synchrotrons led the way to a now large body of work, in particular, in transition metal oxides. However, the analysis of RIXS measurements is still complicated by the complexity of the scattering process, which involves the creation of a high-energy 1s-4p exciton, which scatters of the valence electrons before decaying. In this project we investigate the possible presence of signatures of strong electron-lattice interactions in RIXS in probing the electronic excitations of the solid.

RESULTS

The material we chose for this investigation is the bilayer manganite $La_{2-2x}Sr_{1+2x}Mn_2O_7$. For $x \approx 0.36$ this material exhibits the well-known colossal magnetoresistance (CMR) associated with the transition from a high temperature short-range charge-ordered insulating phase to a low temperature ferromagnetic metallic. On applying a magnetic field near T_C the resistance decreases by up to three orders of magnitude.

A natural coupling between the lattice and electronic degrees of freedom is introduced by the presence of Jahn-Teller active Mn^{3+} ions (1-x of all Mn ions). In order to lower the total energy of the system the single e_g electron occupies only one of the initially two degenerated orbitals, thus, introducing a distortion of the MnO_6 octahedron along the main axis of the occupied orbital (see fig. 1).

Indeed, inelastic neutron scattering measurements have revealed an extremely strong electron-lattice interaction for certain lattice vibrations (phonons), the atomic displacement patterns of which closely resemble the distortions introduced by the Jahn-Teller active Mn ions [1]. In detail, the frequency and linewidth of these phonons showed typical strong coupling behavior, i.e. softening and broadening towards low temperatures.

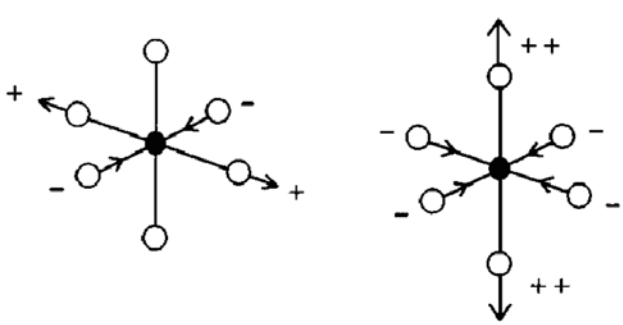

Fig. 1 Atomic movements in one MnO_6 octahedron for the so-called Jahn-Teller mode (left) and the planar breathing mode (right).

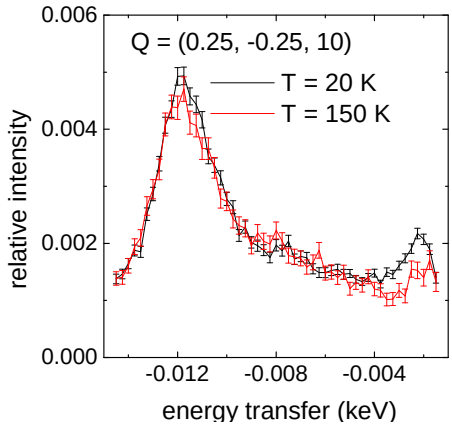

Fig. 2 Background subtracted RIXS spectra of $La_{1.28}Sr_{1.72}Mn_2O_7$ (x=0.36) at two temperatures below and above the metal-insulator transition. The low energy orbital excitation around 2.5 eV is clearly visible in the metallic state.

One might think that such a strong coupling behavior can be seen on 'both ends', i.e. in lattice as well as in electronic excitations. Angle resolved photo emission spectroscopy identified 'kinks' in electronic dispersions near the Fermi level in bilayer manganites [2,3]. However, the response of the orbital excitations (in the range of some eV) to the strong electron-lattice interaction is unclear. The fact that the observed strength of the electron-lattice interaction strongly depends on the position in reciprocal space, **q**, allows us to address this question not only as function of temperature but of wave vector as well.

In a first attempt we measured RIXS spectra of optimally doped $La_{2-2x}Sr_{1+2x}Mn_2O_7$ single crystals. Scans were taken at different wave vectors along the (110) direction in reciprocal space. At **q** = (¼, ¼, 0), were neutron data showed a strong peak of the electron-lattice interaction strength, scans were taken at different temperatures, below and above the metal-insulator transition temperature T_C = 135 K (see fig. 2). First results show a clear peak at ~2.5 meV exhibiting a distinct temperature and wave vector dependence.

ACKNOWLEDGMENTS

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